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LEAF ANATOMY AND PROXIMATE COMPOSITION OF SOME GRASS SPECIES GRAZED BY SMALL RUMINANTS IN MIDWESTERN NIGERIA: A CONSIDERATION FOR SELECTIVITY OF FODDER GRASS

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ABSTRACT

Ten grass species, namely *Axonopus compressus, Cynodon dactylon, C. nlemfuensis, Eleusine indica, Panicum maximum, Paspalum scrobiculatum, Pennisetum purpureum, Rottboellia cochinchinensis, Saccharum officinarum,* and *Sporobolus pyramidalis grazed by goats and sheep in Midwestern Nigeria were selected for investigation. This investigation included the leaf anatomy and the proximate composition of the selected grasses. Some of the grass species were found to be genetically better accumulator of nutrients in their leaves than others and therefore had higher levels of specific nutrients when found growing in the same environment. Rottboellia cochinchinensis accumulated the highest level of protein whereas Paspalum scrobiculatum accumulated the least. However, possession of certain leaf features as macro hairs, opaline bodies, prickles and papillae had significant effect in selectivity of grass species. R. cochinchinensis was seldom grazed on in spite of its high protein content, fairly succulent nature with reasonable amounts of energy substances and mineral salts. Based on their nutritive value vis-à-vis epidermal features, P. maximum, E. indica, and C. nlemfuensis have been recommended for rangeland development for sheep and goats in Midwestern Nigeria.*

INTRODUCTION

Grass is the natural food for all domesticated herbivores and is the only single food of which they can be maintained in good health. Even in countries where the productivity of the farm animal has been raised to high levels and very intense systems are followed, grass is still the fundamental basis for herbivores rations [15]. In Nigeria, the vast herds depend for their livelihood almost entirely on grasses, aided by crop residues, weeds, leaves and seeds of trees and bushes [19].

Increasing demand and subsequent high cost of conventional animal feed ingredients in the tropics have created the need for sustainable alternatives, particularly natural feed resources indigenous to the region [1,24, 25, 30]. Okoli *et al.*[22] observed that this search for alternative feed resources has over the past few decades rekindled research interest in the use of tropical browse plants as sources of nutrients for ruminants as well as non-ruminants.

Although Aletor and Omodara [5], Oji and Isilebo [21] and Okoli *et al* [22] among others, have characterized the nutrient composition of some indigenous browse plants of southern Nigeria. Field observations by the authors however revealed that selectivity of grazing by these small ruminants was not a factor of which browse was more nutritious.

The present study therefore compares the variations in the proximate compositions of fodder grasses commonly grazed by goats and sheep in Midwestern Nigeria in order to underscore their suitability for intensive livestock projection.

MATERIALS AND METHODS

Sources of materials

The common fodder species used in this study was selected after 6 weeks of field observations of free-range sheep and goats at locations (Ekpoma, Igueben, Ubiaja, Uromi) in Midwestern Nigeria. Selection was based on those grass species on which the ruminants preferentially grazed under free range. Mature green leaves harvested at the early period of rainy season as well as dry seasons of 2004 and 2005 were used in the present study.

The dry season samples were investigated to evaluate seasonal variations in the nutrients among the species under study. The grass species selected were: *Axonopus compressus, Cynodon dactylon, C. nlemfuensis, Eleusine indica, Panicum maximum, Paspalum scrobiculatum, Pennisetum purpureum, Rottboellia cochinchinensis, Saccharum officinarum,* and *Sporobolus pyramidalis.* These were selected after six (6) weeks of intense observation of range sheep and goats. Selection was thus based on preference by the animals. Even though *R. cochinchinensis* and *S. officinarum* were seldom grazed they were included to serve as check on the other species.

Chemical analysis

Proximate analysis of fresh foliage of the selected browse plants was determined following the procedures of Allen [6] and AOAC [7]. The parameters studied were crude protein, total ash, crude fibre, oil, starch and minerals (Na, Ca, K).

Test for frequency of selectivity

Ten randomly selected eight-month-old goats and sheep were randomly allocated to cages in each of the areas under study. Fresh foliage of the ten already selected browse plants was harvested daily during the wet season (WS) and 1000g of each grass was fed to each animal. The forage was offered as the whole source of nutrient in two equal portions during the morning (8.00 am) and evening (6.00 pm) during the period of investigation, which lasted for 3 weeks. Residues of the previous day's feed were collected and weighed to determined weight of leftovers. At the end of the experiment, frequency for selectivity was determined as the proportion of the total quantity of foliage given to the animal that was actually consumed during the entire period of study.

Leaf anatomical studies

Free hand sections of the lamina through the central mid-rib were obtained following the methods of Gill and Mensah [11].

Results were pooled and the mean values used in subsequent analyses.

RESULTS AND DISCUSSION

The proximate composition of the ten grass species under study is presented in Table 1. This supplies clues in research, to plants of potential value for further *in vitro* or *in vivo* studies [10, 14]. Proximate analysis is specifically useful in screening the potentials of the array of tropical browse plants utilized by indigenous farmers for ruminant feeding.

The crude protein (CP) content of the grass species under investigation at WS ranged from 7.81%-15.24% DM with the highest in *R. cochinchinensis* and the lowest in *P. scrobiculatum.* The mean value for CP (10.39% DM) compares favorably with that of cassava leaf meal [14] and also meets the minimum protein requirements of ruminants (10.0-12.0%) estimated by ARC [8]. Mean CP content was however not comparable to that of most tropical grass species, which seldom exceed a level of 15% [28]. At the highest CP value of 15.24% DM in *R. cochinchinensis,* none of the plants under study compared favorably with *Leucaena* spp. (22.2% DM) and *Gliricidia* spp. (22.5%DM) [17], and with *Vernonia amygdalina* (17.92%DM) [22], which are also common browses of Southern Nigeria.

The crude protein value of 11.42% for *Panicum maximum* in WS and 7.56% in DS, is higher than 4.85% recorded by Adegbola and Mecha [2] and 2.48% - 3.48% reported by Obioha and Ndukwe [20] for different varieties of *Panicum maximum* harvested in Mid-December. The crude protein value for *Cynodon nlemfuensis* was 8.94% (WS) in the present study. However its DS value was 5.80%, which confirms the observation recorded by Raharjo *et al* [27] at 5.78%.

Most studies reporting the quality and the value of diets are concerned mainly with protein. This is because CP is closely related to other parameters of nutrient value and has been shown to have an overriding influence on animal performance [33]. Milligan [16] has reported maximum CP of 8-9%DM of grasses in the WS harvest in northern Nigeria. However, the present study shows that the range could be as high as 10-15% DM in the sub-humid zone of Edo State of Nigeria. The present study shows that the wetter the vegetation zones, the higher the CP. Results also indicate significant reductions in certain nutrients during the dry season (Table 1). This calls for more intense studies on the zonal as well as the seasonal variations in CP of grass species *vis-à-vis* other feedstuffs for rangeland development and management.

The crude fibre (CF) content of the grasses ranged between 26.42% for *C. dactylon* to 33.62% in *S. officinarum* for WS samples, and from 30.83% in *C. dactylon* to 37.04% for *A. compressus* in DS samples. These values are similar to those of Adegbola and Mecha [2] but lower than those of Carew *et al* [9], who reported up to 40% crude fibre, and higher than those recorded by Raharjo *et al.,* [27]. The mean CF content of the ten plants (31.22%) was however lower than CF levels of cassava leaf meal (15.6%) and guava leaves (16.1%) earlier reported by Aduku [3]. Uwechue [31] also reported that CF of some tropical grass species may be as high as 45% to 50% at more mature stages of growth. The CF content of the plants is an index of available energy value because of their digestibility and possible laxative property. It is also an indication of its lignin content. Although ruminants have high digestibility for lignin, they were observed, in the present study, to avoid high fibre-containing feedstuff in the field such as *Rottboellia cochinchinensi and Saccharum officinarum.*

The oil content estimated as ether extract (EE) from the leaves of all grasses ranged from 1.25 to 3.33 % (WS) and 1.80 to 3.22 %(DS). The mean EE content was low at 2.47%. A high EE content at 5.25% was obtained in *P. scrobiculatum* during the DS. This value is however not comparable to the 8.32% and 7.5% obtained from palm kernel cake and rice bran respectively [3]. Grasses are generally known to contain low levels of oil. The results of this study are thus in line with those of Adegbola and Mecha [2] who observed a similar range (1.80 – 3.95%) for a number of forages from Southern Nigeria.

Together with oil, starch content of the forage provides major energy-giving substances to livestock for tissue maintenance, body heat and locomotion. Energy reserves are also drawn in times of stress for survival, reproduction, lactation, and wool growth. Starch content ranged from trace amounts in *A. compressus* to 9.42 % DM in *P. maximum.* Starch was present in trace amounts in *A. compressus* and *R. cochinchinensis,* which probably store their carbohydrates in forms other than starch.

Most of the ash content is attributable to the mineral contents of the leaves. Thus the younger leaves collected at first harvest, during the WS, had higher minerals as well as ash content (Table 1). Mean ash content at WS (9.26%DM) was comparatively lower than those of *Vernonia amygdalina* (12.80%), *Palisota hirsute* (10.80%) and *Ricinodendron heudelotti* (9.80%) reported by Okoli *et al.,* [22], *Leucaena* spp. (11.0%) by Alekan [4], and cassava leaf (16.07%) by Oyenuga [26]. Potassium content

ranged from 1.32% DM in *S. pyramidalis* to 5.14% in *E. indica* in WS samples, and from 1.05% in *C. nlemfuensis* to 4.42% in *E. indica* in DS samples [32]. Sodium concentration ranged from 0.01%DM in *S. pyramidalis* to 0.08%DM in *P. purpureum* is slightly higher than that reported by Omoregie [23] in the sub-humid zone of Nigeria. However, it is normally considered that 0.015%DM Na in diet is satisfactory for most classes of livestock. *Andropogon gayanus* contains less ash content than *Cynodon nlemfuensis* [1]. The concentration of Ca in the leaves is of special interest in lactating mothers [23 ; Table 1]. Species preferences for domestic stock grazing in savanna land of West Africa are well documented by ILCA [12].

Variation in nutritive quality of the species with age was also observed in the present study. Norton [18] attributed this variation in the nutrient content of browses to within species differences, plant parts, season, harvesting regime, location, soil type and age. Some species are better accumulators of nitrogen, oil, and starch than others and so tend to have higher levels of these minerals than others growing in the same environment. There were considerable increases in the nutritional content in samples taken 8 weeks after the first harvest (flowering stage). This confirms earlier reports by Isichei [13] and Milligan [16]. Isichei [13] summarized the trend of nitrogen concentration in major savanna grasses in Nigeria. The above ground nitrogen concentration is low during dry season as it is usually affected by burning, but there is an exponential increase in concentration at the lush and early period of growth, which is at the beginning of the rainy season when the maximum crude protein content occurs. Isichei [13] had showed earlier that nutritive value of the grass species decrease with age. The younger tender leaves are more nutritious than the older dry leaves. The interval between the cuttings has probably the same effect on the chemical composition as the progressive maturity [25].

Statistically non-significant differences ($p>0.05$) were observed from the four locations under study. Preliminary investigations revealed that the most preferred grass species among the ten species under investigation were *Panicum maximum, Cynodon nlemfuensis,* and *Eleusine indica*. *Rottboellia cochinchinensis* and *Saccharum officinarum* were seldom grazed (Table 2). This observation is particularly interesting, as *Cynodon* species constitute less than 10% of the individual grass species encountered within the area of study.

Leaf anatomical studies

The transverse section of leaf anatomy revealed that all the ten species under study had Kranz anatomy. Double bundle sheath with C4 photosynthetic pathway and a high portion of fibre usually characterize this. The efficiency of conversion of tropical pastures to animal products is lower than that of most improved temperate pastures because of their anatomical and physiological features relating to photosynthesis. Some plant structures are most digestible than others. For example, leaf epidermal features are important for selectivity and intake. Leaves of such epidermal features like macro hairs, papillae, prickles, opaline bodies, etc, are rarely selected (Table 3).

The present study gives a high indication that these features are important for selective grazing exhibited by livestock. For example, the leaves of *R. cochinchinensis* had the highest crude protein content, fairly succulent with reasonable amounts of other energy substances and mineral salts. Yet it is seldom grazed on because it has prickles on the leaf margin as well as on the surface. It also has lots of macro hairs and other pubescent hairs.

From the present study it has been revealed that it is possible to feed small ruminants such as goats and sheep with grass leaves produced at the beginning of the rainy season. This could provide all the nutritional requirements for the survival of the animal through out the year. However during the dry season, there is need to supplement their feed with grass silage from early rain harvest or browses to keep them in

good health. This is because there is usually a decline in the nutrient value of the leaves during the dry season, and this is likely to be non-productive.

The leaf anatomical features also become somewhat paramount when considering selectivity of grass species as whole feedstuff *vis-à-vis* the nutritive value. Based on the proximate analysis, it is recommended that rangeland development or selection of grass for feeding these animals should include *P. maximum, E. indica and Cynodon* species.

Table 1: Nutritive value of some fodder grass of Mid-western Nigeria (weight; percentage dry matter)

Grass species	Season	Crude protein (CP)	Crude fibre (CF)	Ether extract (EE)	Starch (S)	Ash (A)	Nitrogen (N)	Potassium (K)	Sodium (Na)	Calcium (Ca)
Axonopus compressus	WS	10.38	33.20	2.61	Trace	7.81	1.66	2.23	0.07	0.41
	DS	7.16	37.04	2.68	0.01	6.44	1.15	2.01	0.04	0.31
Cynodon dactylon	WS	13.10	26.42	2.11	8.80	10.60	2.10	2.76	0.05	0.86
	DS	9.20	30.83	1.80	7.61	9.06	1.47	1.96	0.03	0.99
C. nlemfuensis	WS	8.94	32.81	1.25	6.82	9.78	1.43	1.52	0.02	0.28
	DS	5.80	35.96	2.05	5.27	6.55	0.93	1.05	0.02	0.27
Eleusine indica	WS	8.90	31.20	2.40	6.50	9.40	1.42	5.14	0.02	0.47
	DS	6.79	36.04	3.11	6.04	6.95	1.09	4.42	0.05	0.83
Panicum maximum	WS	11.42	31.81	2.73	9.42	11.86	1.83	1.92	0.04	0.68
	DS	7.56	35.31	2.01	7.28	8.42	1.20	1.90	0.03	0.14
Paspalum scrobiculatum	WS	7.81	30.16	2.05	4.13	8.78	1.25	1.50	0.02	0.44
	DS	5.45	32.18	5.25	3.84	6.32	0.87	1.30	0.01	0.40
Pennisetum purpureum	WS	11.13	28.20	3.33	8.20	9.98	1.78	2.06	0.08	0.84
	DS	8.14	32.54	2.11	6.35	8.58	1.30	1.99	0.06	0.92
Rottboellia cochinchinensis	WS	15.24	32.89	3.21	Trace	9.82	2.44	2.42	0.03	0.43
	DS	9.52	35.36	3.25	0.01	8.78	1.52	2.08	0.02	0.46
Saccharum officinarum	WS	9.27	33.62	3.07	1.63	6.35	1.48	2.96	0.02	0.51
	DS	8.98	36.97	3.22	1.05	6.38	1.44	1.99	0.02	0.46
Sporobolus pyramidalis	WS	7.72	31.90	1.89	1.09	8.23	1.14	1.32	0.01	0.21
	DS	5.77	36.85	1.98	1.00	7.15	0.92	0.99	0.01	0.30
Mean value	WS	10.39	31.22	2.47	4.70	9.26	1.65	2.38	0.04	0.51
	DS	6.54	34.91	2.75	3.85	7.46	1.19	1.97	0.03	0.51
LSD (0.05)		1.95	3.32	0.97	1.56	7.13	0.85	0.85	0.01	0.09

Table 2: Grazing selectivity ranking of grass species based on field observations.

S/N	Grass species	Relative frequency of grazing (%)
1	*Axonopus compressus*	9.8
2	*Cynodon dactylon*	9.6
3	*C. nlemfuensis*	19.8
4	*Eleusine indica*	13.6
5	*Panicum maximum*	19.3
6	*Paspalum scrobiculatum*	5.6
7	*Pennisetum purpureum*	8.7
8	*Rottboellia cochinchinensis*	3.3
9	*Saccharum officinarum*	3.7
10	*Sporobolus pyramidalis*	6.6
	Total	100

Table 3: Leaf anatomical features that limit selectivity and intake of grass species under study.

Grass species	Surface	Region	Macro hair	Prickle	Papilla	Opaline body
Axonopus compressus	AD	C	-	-	-	DB
		IC	-	-	-	-
	AB	C	-	-	-	DB
		IC	-	-	-	-
Cynodon dactylon	AD	C	-	+	-	SD
		IC	+	-	+	TN
	AB	C	-	+	-	SD
		IC	+	+	+	TN
C. nlemfuensis	AD	C	-	+	-	SD
		IC	-	+	-	TN
	AB	C	-	-	-	SD
		IC	-	-	-	TN
Eleusine indica	AD	C	-	-	-	SD
		IC	-	+	-	TN
	AB	C	-	-	-	SD
		IC	-	-	-	TN
Panicum maximum	AD	C	-	+	-	DB
		IC	-	+	-	-
	AB	C	-	+	-	DB
		IC	-	+	-	TN
Paspalum scrobiculatum	AD	C	-	-	-	DB,
		IC	-	-	-	CR
	AB	C	-	-	-	CR
		IC	-	-	-	DB
						-
Pennisetum purpureum	AD	C	-	+	-	DB
		IC	+	+	-	TN
	AB	C	-	+	-	DB
		IC	+	+	-	TN
Rottboellia cochinchinensis	AD	C	-	+	-	DB,
		IC	+	+	-	CR
	AB	C	-	-	-	CR
		IC	-	-	-	DB
						-
Saccharum officinarum	AD	C	-	+	-	CR,
		IC	-	+	-	DB
	AB	C	-	+	-	CR
		IC	-	+	-	CR,
						DB
						DB
Sporobolus pyramidalis	AD	C	-	+	-	SD
		IC	-	+	-	TN
	AB	C	-	-	-	SD
		IC	-	+	-	TN

C= Costal zone
IC= Intercostal zone
+ = Present
- = Absent

TN= Tall and narrow
DB= Dumb bell shaped
CR= Cross shaped
SD= Saddle shaped
AD= Adaxial surface

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